Operational Concept Validation Process

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OPERATIONAL CONCEPT VALIDATION PROCESS

1 INTRODUCTION

Improvements in safety, capacity, and efficiency are forces that are driving a transition from today's National Airspace System (NAS) to a more flexible and economically beneficial future aviation system. For several years, the Federal Aviation Administration (FAA), other government organizations, and industry have focused on developing a modernization plan for the NAS. Their collaboration has yielded a FAA Air Traffic Services (ATS) Concept of Operations for the NAS in 2005 and a complementary NAS Architecture. To ensure that the desired improvements will be achieved, the proposed operational concepts must be validated and the corresponding technologies and procedures must be accurately assessed.

At the request of the NAS Concept Development Branch (ASD-130) and Air Traffic Planning Division (ATP-400, formerly ATO-400), an ad hoc group of engineers, scientists, and management personnel was formed to develop a general process to validate the ATS Concept of Operations. This group, chaired by the NAS Advanced Concepts Branch (ACT-540), includes members from the NAS System Engineering and Analysis Division (ACT-500), Chief Scientist, Human Factors Division (AAR-100), Investment Analysis and Operations Research Division (ASD-400), MITRE CAASD, NASA, and supporting contractors. Their collaborative efforts are presented in this Operational Concept Validation Process (OCVP). The process is intentionally general in the sense that it provides an overview of the types of activities needed for concept validation. Details of specific experimentation plans will be presented separately as validation plans for specific concepts are formulated.

The OCVP fully supports the priorities expressed in the Associate Administrator for Research and Acquisition Performance Plan and in the Air Traffic Services Performance Plan. Further, the OCVP is responsive to the policies, principles, and processes established by the FAA Acquisition Management System (AMS). Finally, the process recognizes the need to validate the concepts within a framework that accurately reflects the true nature of the current and future NAS. The framework set forth in the OCVP recognizes the strong linkage between the NAS environment entities, such as *people* who operate the NAS, the *machines* that provide information and support decision making, and the *procedures* used to safely operate within the NAS.

1.1 Purpose and Scope

The OCVP describes the strategies and mechanisms that will be used to validate the ATS Operational Concepts. For the purpose of this document, the term *concept validation* is defined as the systematic evaluation of a concept to determine its operational impact on NAS users and service providers. A concept is considered "valid" if it provides an operational benefit and meets established user and service provider goals related to safety, capacity, efficiency, predictability, flexibility, and accessibility.

The goal of the validation process is to assess the concepts to ensure operational feasibility, to quantify expected benefits, and to support resolution of NAS architectural issues. Specifically, the proposed concepts will be examined to determine if they are:

- Necessary – Determine if all proposed concepts are needed to satisfy the objective(s) of the operational functions and provide operational benefits to users and providers, and
- Sufficient – Determine if all operational aspects have been completely addressed. If necessary, identify additional concepts needed to provide operational benefits to users and providers.

By exploring operational concepts in a benign operating environment, such as in a laboratory, we will be able to identify concept deficiencies and recommend potential solutions.

1.2 Benefits of Concept Validation

The operational concept validation process is necessary for evolving the NAS in response to user and agency needs of increased safety, capacity, efficiency, predictability, flexibility, and accessibility. The validation process will:

1. Determine if the NAS concept of operations is operationally feasible.
2. Determine if the concepts need to be modified based on research and empirical data.
3. Provide information for developing operational, procedural, automation, decision support system, and training requirements with due consideration to human factors issues. This will ensure that the system will be human-centered and human factors considerations will be taken into account in the early phases of the AMS, thereby supporting the development of the system requirements.
4. Provide a foundation for developing and modifying the future NAS architecture.
5. Provide information to support cost-benefit analyses.
6. Insure the appropriate capabilities are deployed to service providers to meet the agency/industry goal of moving toward Free Flight, as articulated in the RTCA Free Flight Action Plan.

Concept validation early in the development cycle provides an opportunity to assess each concept to determine its impact on operations prior to significant investment decisions. Further, validation provides an opportunity to begin developing the procedures necessary for implementing the concepts, thus ensuring that such procedures are in place when the capability becomes available.

1.3 Acquisition Management System

The Air Traffic Management System Performance Improvement Act of 1996 expanded the procurement reforms previously authorized by the 1996 DOT Appropriations Act. The FAA AMS, established in 1996, provides a framework for informed decision making within the Integrated Product Teams' (IPTs) structure. The AMS incorporates system engineering principles and processes to evaluate new concepts. As shown in Figure 1, the AMS consists of five phases: Mission Analysis, Investment Analysis, Solution Implementation, In-Service Management, and Service Life Extension.

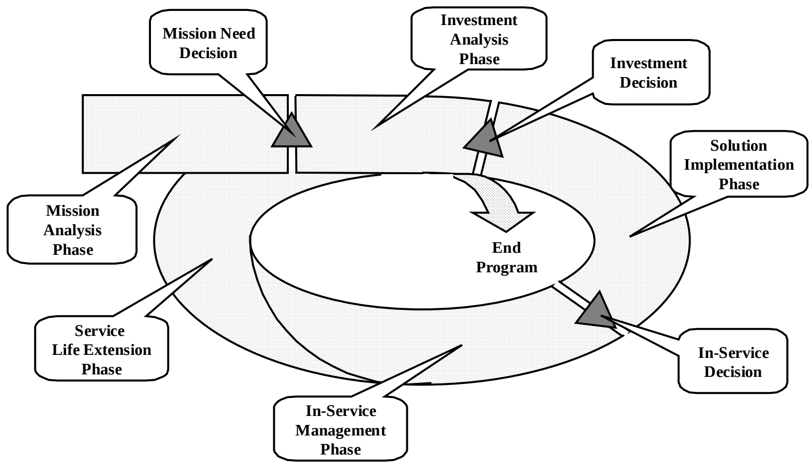

Figure 1. System Life Cycle

The relationship between the validation process and the AMS is two-fold. First, the validation process helps establish the mission needs that drive the NAS evolutionary development. The Mission Analysis phase of the AMS is where capability shortfalls are identified and quantified, and alternative solutions for eliminating the shortfalls are identified. The validated operational concepts provide the context in which alternative solutions are identified. The capability shortfalls and potential alternative solutions form the basis for the Investment Analysis in the next phase of the AMS.

Second, as alternative solutions are examined in the Investment Analysis phase, cost estimates for implementing the validated concepts are developed. At this point, proposed changes to the concepts are submitted to ATS for consideration, and any resulting changes to the operational concepts are submitted for further validation prior to acceptance.

1.4 Iterative Operational Concept Development

The validation process is an on-going process throughout the operational concept development activity. Figure 2 illustrates how the validation process interfaces with the overall operational concept development process. Initially, the results of the validation process are reviewed by ATS in coordination with the user community to determine if changes should be made to the proposed operational concepts. If the concepts need to be changed, the revised concepts are re-inserted into the validation process. Aside from the results obtained from concept validation, budget concerns and changing needs may have a potential impact on the direction of the operational concepts.

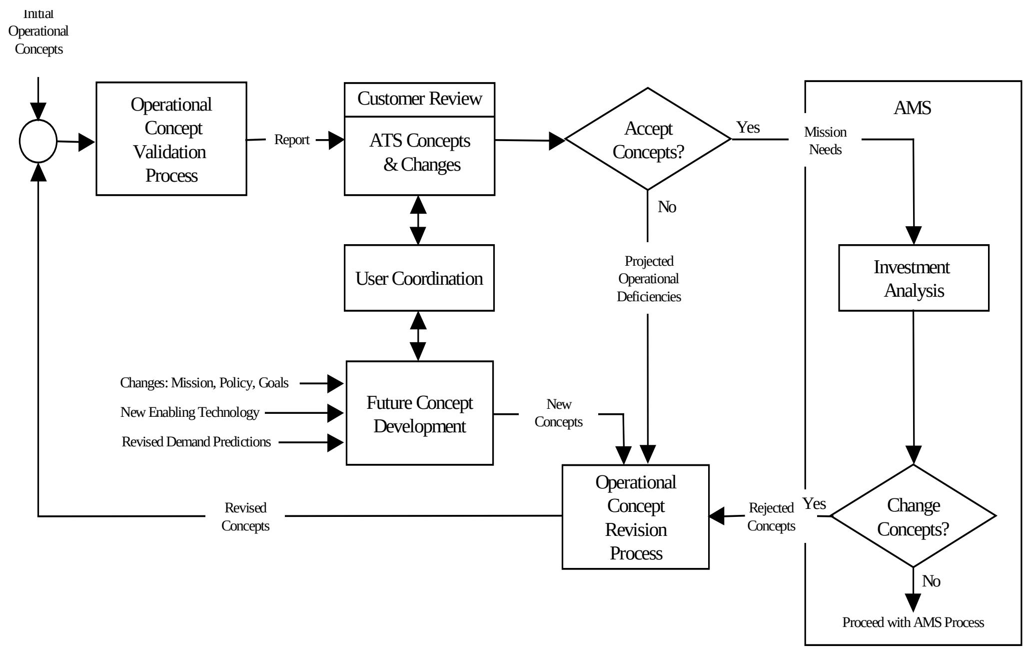

Figure 2. Operational Concept Development

1.4.1 Budget Concerns

A potential source of changes to the operational concepts requiring validation is the results of the Investment Analysis phase of the AMS. In such cases, the validation process will be used to assess the proposed concepts in terms of operational performance within pre-defined metrics, which will not include the cost to implement. The Investment Analysis phase may indicate that all of the alternatives for implementing the operational concepts would exceed budget limitations and might therefore be unacceptable to the Joint Resources Council. In such a case, changes to the operational concepts might be necessary in order to identify a cost-effective approach to meeting the mission needs. These changes would be developed by ATS and re-inserted into the validation process along with changes in the assumptions, constraints, and performance goals.

1.4.2 Changing Needs

ATS, the user community, and researchers routinely examine the operational concepts for identifying areas of improvement. These improvements may be the result of changes in mission, policy, or goals; changes in enabling technology; and changes in the demand for, or types of services based on evolving user needs and increased utilization of the airspace. The resulting new concepts would be inserted into the validation process along with changes in the assumptions, constraints, and performance goals.

Although the validation process described here can be used to validate future operational concepts, the intent of this process is to focus on the validation of the proposed ATS

Concept of Operations for the NAS in 2005. The reference to future validation efforts is intended to show how the validation process can continue to be useful, and to help justify the expenditure of funds for developing validation tools. It should also be noted that most of the tools used to validate the operational concepts could also be used to analyze specific architecture designs and changes, and requirements at lower design levels.

2 APPROACH

The validation process involves three major phases: Phase I, Problem Definition; Phase II, Analysis; and Phase III, Synthesis. Figure 3 illustrates these three phases.

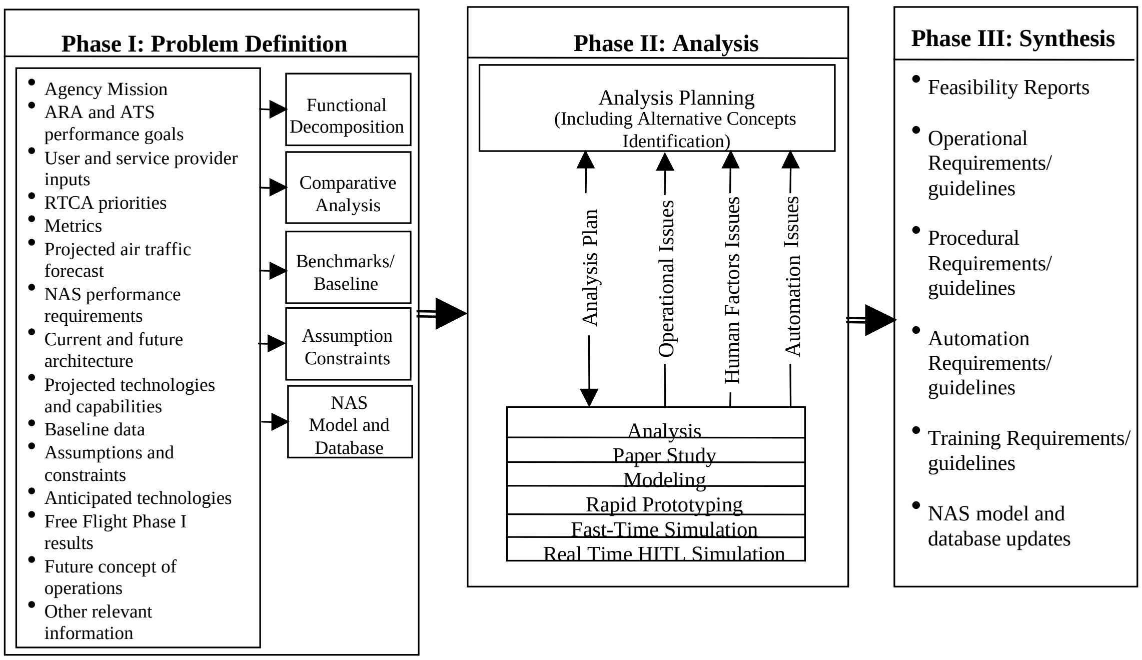

Figure 3. Validation Process Phases

2.1 Phase I: Problem Definition

In the Problem Definition Phase, various user and service provider inputs are integrated to generate a list of issues and problems that require investigation. These lists serve as a basis for developing detailed problem statements that consider the impact of the operational concepts on capacity, efficiency, flexibility, predictability, productivity, accessibility, safety, operator workload, situation awareness, and performance. The problem statement(s) form the basis for the formulation of study plans and experimental designs.

The following information will be considered in the generation of the problem statement(s) for each operational concept:

- Agency mission
- ARA and ATS performance goals
- User and service provider inputs

- RTCA priorities
- Metrics
- Projected air traffic forecasts
- NAS performance requirements
- Current and future NAS architecture
- Projected technologies and capabilities
- Baseline data
- Assumptions and constraints
- Anticipated technologies
- Free Flight Phase I results
- Future concepts of operation
- Other relevant information.

The above information will be consolidated into a more meaningful foundation for the problem definition phase. The foundation will include development of current and future functional decompositions, comparative analysis, assumptions and constraints, benchmarks, and NAS models and databases. In setting the foundation, the baseline NAS performance will be compared to future capabilities as identified in the ATS operational concept document. Since part of the validation involves determining if the concept meets specific NAS performance goals, benchmarks will be derived. These benchmarks consist primarily of the current system performance, and may also include the projected NAS performance. The latter performance would be used to compare the existing NAS against the projected NAS using the same system loading, if such a comparison is deemed necessary for validation of the concept. The performance goals will be translated into specific metrics that will be used to determine the validity or impact of the concepts. Based on available and projected technologies, previous literature, and other factors, various assumptions and constraints will be identified. At the final stage, the NAS model and databases will be developed. These databases and models will be useful for conducting preliminary "what-if" analyses and impact assessments.

2.1.1 Functional Decomposition

A functional decomposition of the services provided within the Surface, Arrival/Departure, En Route, Oceanic air traffic control, and Traffic Flow Management domains as well as the overarching activities of Infrastructure management will identify and document the necessary functionality to provide services to users. As a part of functional decomposition, the allocation of current system functions to people and automation will be done by functional allocation. The functional decomposition will be useful for comparing existing NAS functionality with anticipated future NAS functionality. Appropriate operational procedures outlined in the Air Traffic Control (ATC) Handbook (FAA Order 7110.65) will also be identified and documented for each function. Figures 4 and 5 depict the functional allocation process for the existing and future (2005) NAS.

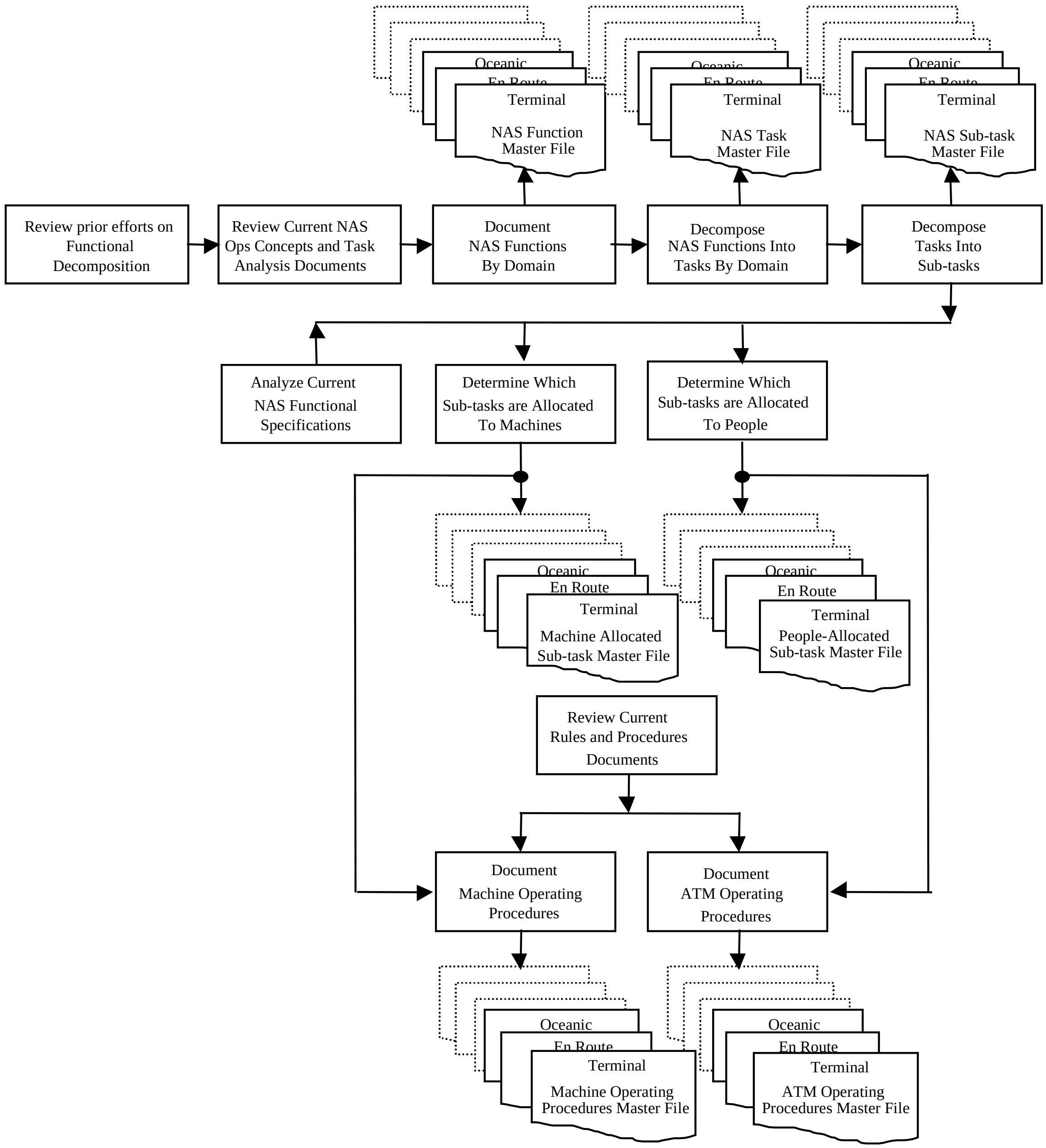

Figure 4. Decomposition Process – Current NAS

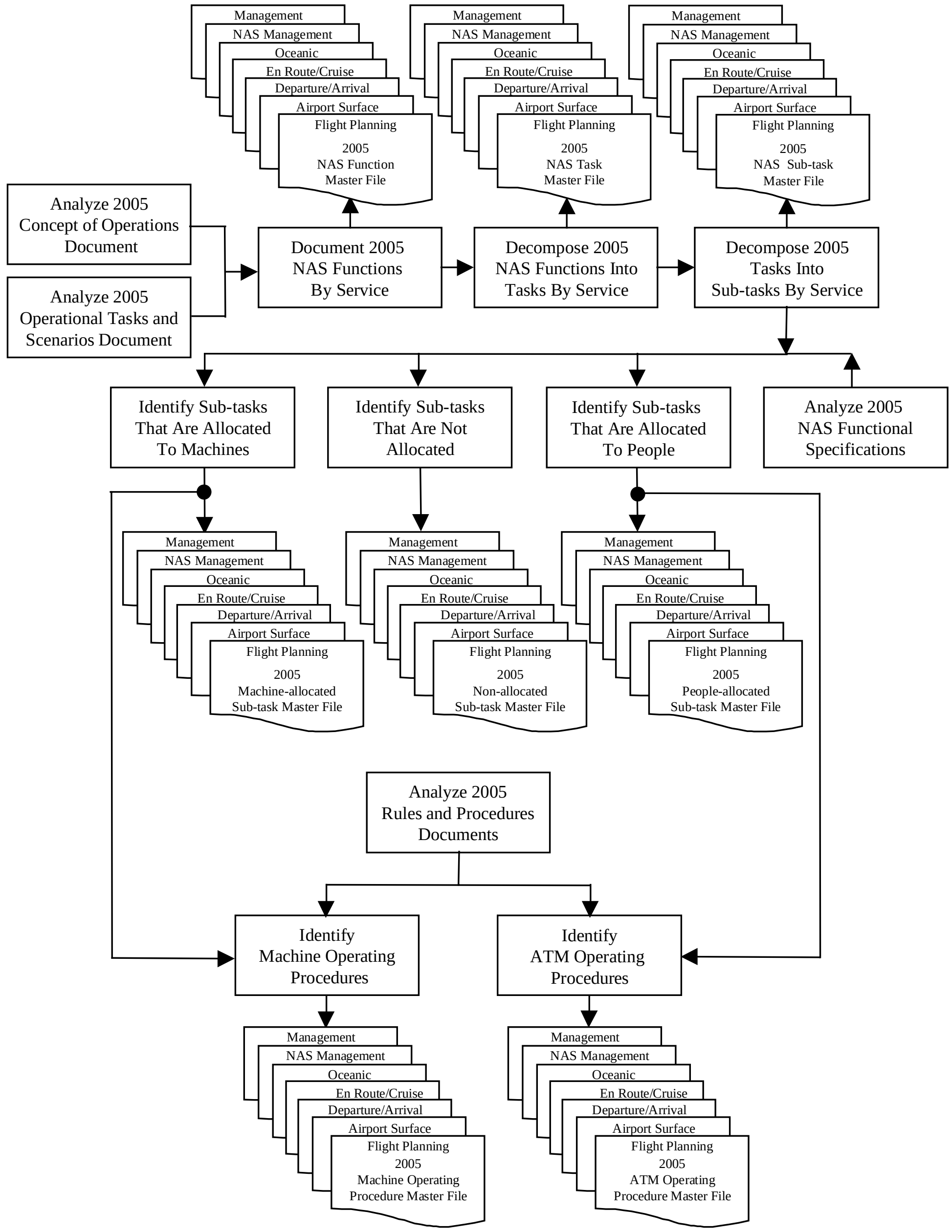

Figure 5. Decomposition Process – 2005 NAS

2.1.2 Comparative Analysis

A comparative analysis of the current NAS decomposition and the 2005 NAS decomposition will facilitate the identification of gaps and overlaps between the current system functionality and the desired system functionality as expressed in the 2005 concept of operations. The gap between where the functionality is and where it should be will provide additional insights and valuable information. These inconsistencies or gaps in desired capabilities will generate a list of issues related to machines, procedures, and people that require resolution. The Operational Concepts Validation Team will prioritize these issues for validation.

2.1.3 Benchmarks and Metrics

As stated earlier, concept validation refers to the evaluation of a concept to determine its operational impact on NAS users and service providers. Since a "valid" concept should provide an operational benefit and meet established user and service provider goals, benchmarks are necessary. The benchmarks will be related to the following categories:

- Capacity
- Efficiency
- Flexibility
- Predictability
- Productivity
- Accessibility
- Safety
- Operator Workload
- Situation Awareness
- Performance

Benchmarks, or "baselines" used herein, most often relate to the performance of the existing NAS, or some other starting point, such as Free Flight Phase1. The intent is to determine to what extent (if any) the performance goals of the proposed concept(s) meet their objectives. It is recognized that many activities are underway to define "standardized metrics." To the extent possible, a standard set of metrics will be utilized. Depending on the specific study objectives, these baseline comparisons will also include a comparison of current and future versions of hardware and software tools.

As detailed concept validation plans are created and implemented, a key element of the plans will be the establishment of a baseline against which the effectiveness of the proposed operational concept can be gauged. Based on this baseline information, detailed metrics will be developed. The metrics will be refined or modified in the analysis phase to suit specific study objectives.

2.1.4 Assumptions and Constraints

Since the concept of operations involves future operations, certain assumptions about technologies, procedures, and traffic forecasts are required. Additionally, constraints such as accuracy and availability of required data, modeling and simulation infrastructure, budgets, and schedules must be considered.

2.1.5 NAS Models and Databases

A repository of NAS models and databases are currently available to support the validation process. At present, the FAA uses such models and databases[1] for determining the impacts of advanced concepts, technologies, and procedures on the NAS. Additionally, work is underway to develop a NAS model that will consider the relationship among NAS services, functionality, and performance. This model will be useful for conducting "what-if" analyses and exploring interactions among different equipment, people, and procedures. Such models and databases will help focus on the bottlenecks, problem areas, and study parameters.

The activities described in Phase I, such as the functional decomposition, comparative analysis, benchmarks and metrics, and assumptions and constraints are necessary to support Phase II.

2.2 Phase II: Analysis

The Analysis Phase involves the planning, design, research method selection, conduct, and data collection and reduction activities. Proven scientific and research methods are paramount for conducting concept validation. The accuracy of the results of the validation process will depend on the types of methods used, the assumptions made, and the study constraints. The validation process will consist of the following methods:

1. *Paper studies:* The paper studies will be used for conducting target level of safety analysis, risk analysis, cost-benefit trade-off analysis, and examining theoretical aspects of the concept of operations. These studies may include gap analysis, functional decomposition, comparative studies, analytical studies, etc. Some of these studies may fall under the Problem Definition Phase depending on the study specifics.
2. *Fast-time simulation studies:* The fast-time simulation studies will be used for conducting capacity, safety and efficiency analysis. Typical studies include airspace analysis, delay analysis, capacity analysis, and safety analysis.
3. *Modeling:* The analytical models will be used to predict the impact of new concepts on operations including capacity, safety, and efficiency.
4. *Real-time human-in-the-loop (HITL) studies (part-task and end-to-end):* The real-time HITL simulation studies will be used to examine the impact of the concepts on operator workload, operator situation awareness, and to assess overall system performance and safety.
5. *Rapid prototyping:* The rapid prototyping studies will provide an opportunity to develop human-computer interfaces for advanced concepts and conduct usability studies. Although rapid prototyping can be considered as a development activity, the

[1]Among others these models include NARIM, NASPAC, ADSIM, RDSIM, RAMS, SDAT and SIMMOD.

user-interface is often tied with the human and system performance**.** In some cases, rapid prototyping exercises will provide input to real-time HITL simulation studies and vice-versa.

Typically, the following steps are involved in conducting a validation study:

1. *Define study specific objectives:* A clear and concise statement about the objectives will be developed.
2. *Form a team:* The team will consist of members from the operational concept validation management and system analysis team, subject matter experts, union representatives, researchers, statisticians, human factors engineers, sponsors, and other members.
3. *Identify the type of study:* The team will identify the suitable type of study (e.g., paper study, fast-time simulation, real-time simulation, or rapid prototyping) necessary to accurately assess the operational and technical feasibility of the proposed system changes.
4. *Develop experiment plan:* An experiment plan detailing the background, objectives, literature review, procedure, data collection and analysis methods, and schedule will be developed.
5. *Develop detailed metrics:* The team will identify, define, and develop, as necessary, the metrics required to support the objectives of the study.
6. *Develop scenarios and select equipment:* The team will develop air traffic scenarios and select the equipment (e.g., simulator) with due consideration to fidelity requirements.
7. *Schedule laboratory and support personnel:* Team will conduct the necessary coordination to ensure that adequate laboratory time is available and support staff will be available when required. This step is typically only required for real-time, HITL simulation studies.
8. *Conduct shakedown testing:* Trial runs of the scenarios will be conducted to ensure that the scenarios, laboratory environment, and operations are realistic. This step is typically only required for real-time, HITL simulation studies. If necessary, various laboratories need to be integrated and configured to suit study objectives.
9. *Conduct simulation and collect data:* Members of the team will conduct the study and collect the data as outlined in the experiment plan.
10. *Analyze data and develop recommendations:* Once the data is collected, members of the team will analyze the data and develop recommendations. Results from multiple studies aimed at evaluating a single operational concept will be reviewed and merged to form a list of recommendations. The results will also be provided to sponsors and other interested parties via Technical Notes.
11. *Provide data/information to NAS model and database:* The data will be incorporated into the NAS models and databases so that the databases will be updated.

Since the NAS is a complex system with many services and associated performance requirements, different scenarios, as identified in the *Operational Concept Tasks & Scenario* document, will be examined separately, with one or more methods being used depending on the concepts to be verified and the issues involved.

During the development of the study/experiment plan or during the time of evaluation, it may be desirable to examine alternative concepts that represent minor variations of the concepts under examination. Alternatives will be examined to determine if they are optimal and if they require significant architectural changes. In addition, alternative concepts will be explored to identify if they eliminate an operational problem that was discovered during the analysis phase. The results of this alternative analysis will be included in the final report.

2.3 Phase III: Synthesis

The Synthesis Phase involves interpretation of the results generated during Phase II. Interpretation of results will be based on metrics, baseline data, agency performance goals and mission, and other information pertinent to a specific validation study. The results will be translated into a Technical Report or other format such as a requirements traceability matrix. These reports will provide an assessment of the validity of the concepts in terms of the agreed-upon metrics and they will do the following:

- State whether or not the performance goals can be met
- State to what extent the goals cannot be met
- List operational issues discovered during the analysis
- Provide recommendations for potential alternative concepts
- Provide a set of validated operational requirements derived from the operational concepts that were analyzed
- Provide recommendations for procedural changes necessary to implement the concepts
- Provide recommendations for automation and decision support tools necessary to implement the concepts
- Provide information related to human factors issues related to these concepts
- Provide recommendations regarding changes in the NAS Architecture necessary to implement the concepts
- Provide information to update existing models and databases.

Figure 6 summarizes the overall activities and decisions involved in the Problem Definition, Analysis, and Synthesis Phases.

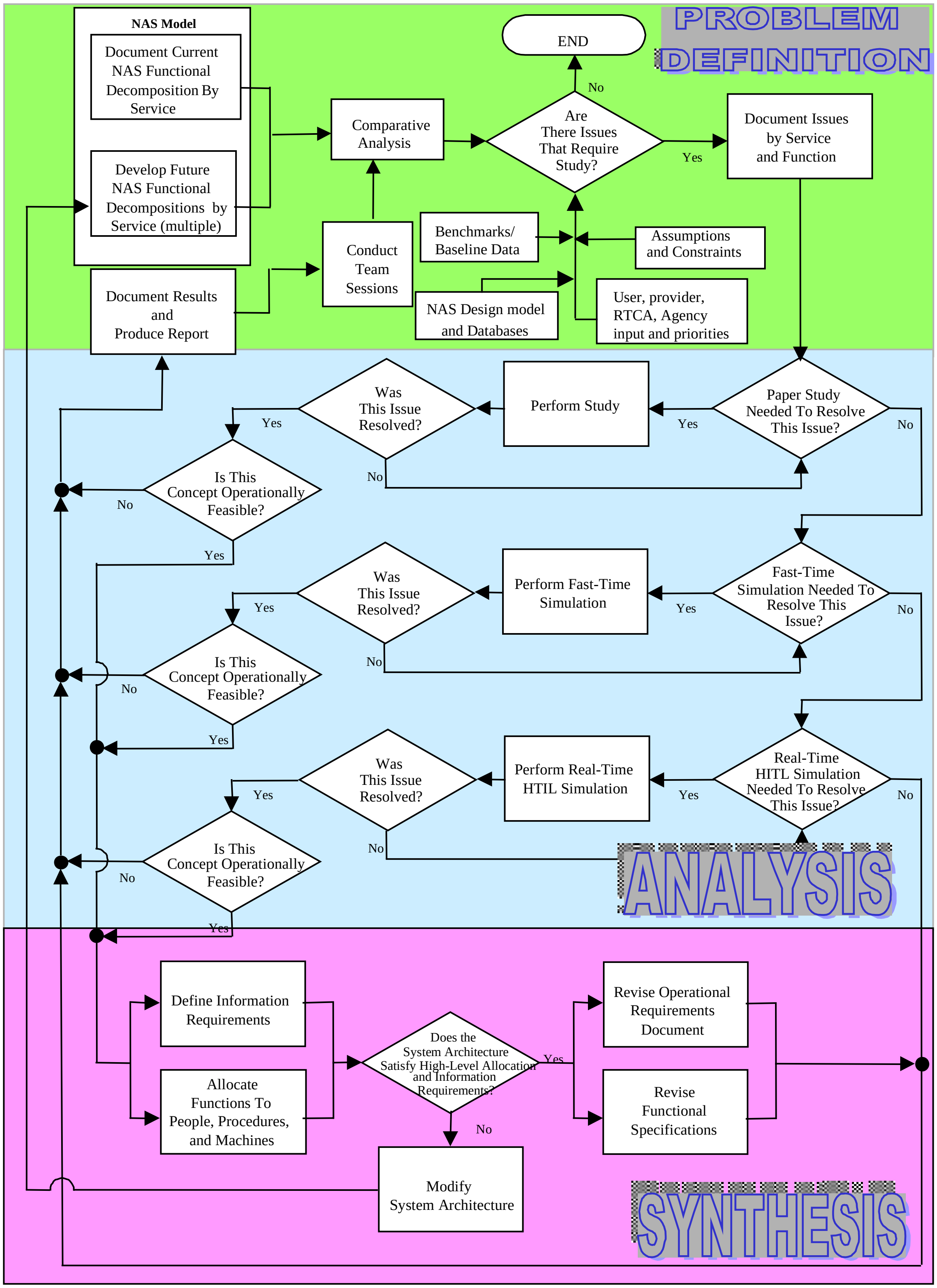

Figure 6. Overall Activities

It is anticipated that the activities in this phase will be highly iterative within themselves and between the Analysis and Synthesis Phases.

2.3.1 Products

The products envisioned from the validation process will focus on the assessment of operational concepts with respect to established metrics. If the operational concepts are deemed valid, the following products will be developed:

- Detailed reports of each study, evaluation or analysis from which operational, procedural, automation, information and system requirements may be derived.
- Database of functional allocations between people and machines that maximize human and machine performance.

Additionally, validation results will be used to enhance and refine existing NAS models and databases. The data captured on operator workload, response times, capacity, efficiency, safety, and other important metrics and parameters will be provided to the Operational Concept Model Integration and Enhancement activity (See Program Management Plan).

3 ROLES AND RESPONSIBILITIES

The execution of the operational concept validation process, and the subsequent development of requirements for the future NAS, requires a diverse team of highly skilled professionals that are cognizant of the operational and technical aspects of the NAS. The Operational Concept Validation Team is comprised of FAA and industry representatives, including participants from various Airways Facilities (AF), Air Traffic, airlines, and labor organizations. The team is partitioned into an oversight management team and system analysis team, the respective roles of which are described below.

The ***management team*** is co-chaired by the Air Traffic Planning Division (ATP-400) and ASD-130, and also includes members from the National Operations Division (AOP-100), NAS Policy Division (AOP-300) and ACT-540. This team is responsible for the following activities:

- Coordinating the development and modifications of the ATS 2005 Operational Concept
- Identifying resources (including funding) and allocating these resources for specific tasks
- Developing a multi-year Program Management Plan describing work activities and their priorities, and budget and resource estimates
- Ensuring that the products derived from the validation process are conveyed to the appropriate FAA organizations and used accordingly
- Ensuring that there will be no duplication of effort
- Ensuring that the respective team members’ capabilities are used to achieve the greatest benefit.

The ***system analysis team*** is comprised of members from the Operations Research and Analysis Branch (ASD-430), ACT-500, AAR-100, MITRE CAASD, and NASA. This team provides the expertise and tools necessary to fully examine the operational concepts by employing various methods used for concept validation. The system analysis team is responsible for the following:

- Developing and implementing of the validation process
- Enhancing the laboratory and model infrastructure and developing the necessary tools
- Establishment of specific study or experiment working groups for the projects identified by the management team
- Coordinating through standard agency process, with necessary subject matter experts, including Airways Facilities, Air Traffic, airlines, and labor organizations for specific experimental research activities
- Developing validation reports and cataloging of relevant documentation.

During individual validation studies (e.g. experimental, modeling, paper or rapid prototyping), subject matter experts (SMEs) representing service providers and users will be included in all phases of the validation process. FAA's AOP, ATP, and Flight Standards organizations will assist in providing these SMEs. During the validation studies, care will be taken to address issues related to both service provider and user operations.

In addition, organizations conducting aviation research determined to be complementary to the validation of specific operational concepts will be included as ad hoc members of this team or conferred with to eliminate duplication of effort. It may also be necessary to involve other organizations such as the NEXTOR Center of Excellence and MIT Lincoln Laboratory.

Finally, the Operational Concept Validation Team will keep abreast of the research activities underway within EuroControl as part of the FAA/EURO Research and Development Committee action plan initiatives and will support the joint FAA/NASA Interagency Integrated Product Team initiatives in ATM concept development and validation. The team will also coordinate and cooperate with other organizations, to the extent possible, in light of joint initiatives and differing operational needs.

4 PROGRAM MANAGEMENT PLAN

The management team will develop a multi-year Program Management Plan describing work activities and their priorities, and budget and resource estimates. The plan will identify the validation studies and other supporting tasks, funding requirements, model and laboratory infrastructure needs, estimated schedules, milestones, and deliverables for each fiscal year. The Program Management Plan will provide an overall strategy for communicating priorities, assigning work, and facilitating the justification of budgetary requirements.

In deriving the Program Management Plan, the management team will consider inputs and incorporate input from various sources including:

- User community (through RTCA)
- FAA service providers (through ATP-400)
- Direction of CNS/ATM technologies (through the NAS architecture)
- Areas where the need for more research is identified (through NASA's "Gap Analysis" activity)
- Domain expertise, research activities, and evaluation capabilities of the system analysis team.

Figure 7 illustrates the various inputs to the Program Management Plan.

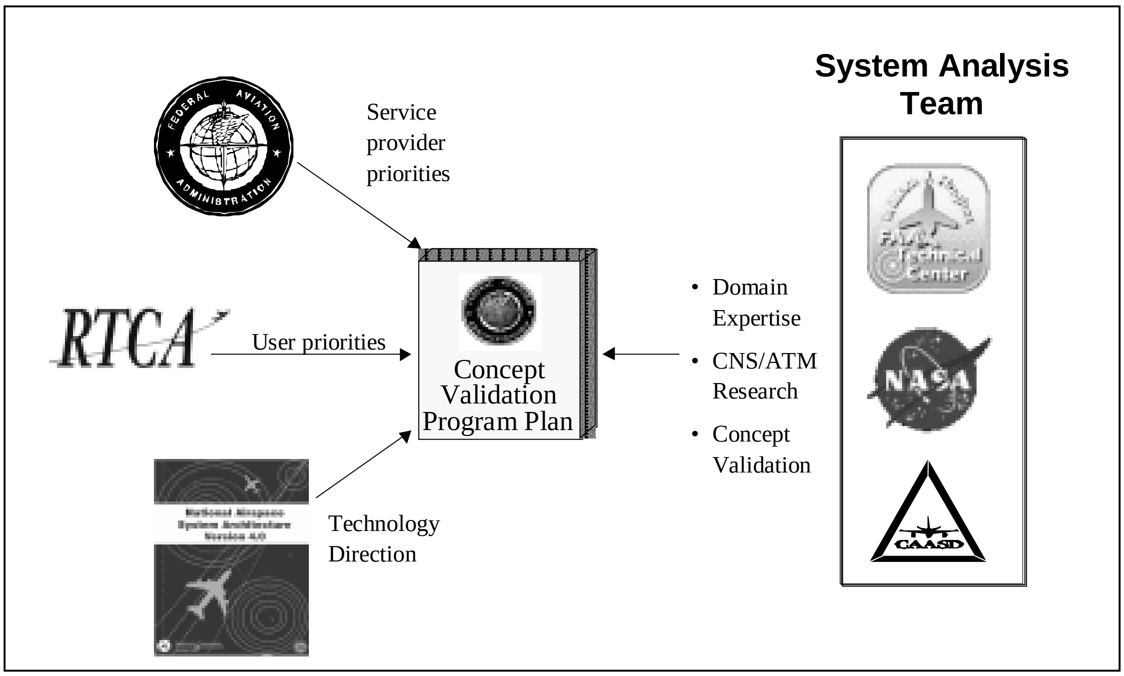

Figure 7. Concept Validation Program Management Plan Development

4.1 Summary

The OCVP provides an overview of the process that will be adopted for validating the concepts described in the ATS Concept of Operations 2005. However, this process can be applied to validate other advanced concepts, technologies, and/or procedures that focus on operational improvements. The OCVP will be updated as necessary to include lessons learned as a result of using this validation process.

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ACRONYMS

ADSIM	Airfield Delay Simulation Model (A fast-time simulation model)
AF	Airways Facilities
AMS	Acquisition Management System
ARA	Associate Administrator for Research and Acquisitions
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CAASD	Center for Advanced Aviation Systems Development (MITRE's division)
CNS	Communications, Navigation and Surveillance
DOT	Department of Transportation
FAA	Federal Aviation Administration
HITL	Human-in-the-loop Simulation
IA	Investment Analysis
IPTs	Integrated Product Teams
MA	Mission Analysis
NARIM	National Airspace Resource and Investment Model (A fast-time simulation model)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASPAC	National Airspace System Performance Analysis Capability (A fast-time simulation model)
OCVP	Operational Concept Validation Process
RAMS	Reorganized Air Traffic Control Mathematical System (A fast-time simulation model)
RDSIM	Runway Delay Simulation Model (A fast-time simulation model)
SDAT	Sector Design and Analysis Tool
SI	Solution Implementation
SIMMOD	Airport and Airfield Delay Simulation Model (A fast-time simulation model)

Organizational Codes

AAR-100	Chief Scientist, Human Factors Division (FAA, Washington DC)
ACT-500	NAS System Engineering and Analysis Division (FAA, William J. Hughes Technical Center)
ACT-540	NAS Advanced Concepts Branch (FAA, William J. Hughes Technical Center)
AOP-100	National Operations Division (FAA, Washington DC)
AOP-300	NAS Policy Division (FAA, Washington DC)
ASD-130	NAS Concept Development Branch (FAA, Washington DC)
ASD-400	Investment Analysis and Operations Research (FAA, Washington DC)
ASD-430	Operations Research and Analysis Branch (FAA, Washington DC)
ATP-400	Air Traffic Planning Division (FAA, Washington DC) – Formerly ATO-400
MITRE	A federally funded research and development center supporting the FAA
RTCA	RTCA (Industry and government joint organization)

GLOSSARY

Accessibility	*Accessibility* to the ATM system and the services provided by ATS is the basic need of all airspace users. Users need to access airports, airspace, and services. To evaluate ATS' ability to meet the varying access needs of its diverse customers, ATS has identified a number of performance measures.
Analysis Phase	*Analysis Phase* involves defining analysis method(s), and conducting analysis for a problem or an issue that needs investigation.
Baseline	*Baseline* generally refers to a system or operational performance that is considered as acceptable for comparison. Generally, the term *baseline* refers to the current system and its operational performance.
Benchmark	*Benchmark* refers to minimum acceptable performance or criteria for a system or operation. A benchmark could be a baseline or an improvement from the baseline. For example, the goal of reducing the number of runway incursions by 20% by the year 2005. Here, the baseline is the number of runway incursions in the year 1999 and the benchmark is a reduction by 20%.
Capacity	*Capacity* refers to the ability of the system to accept, contain and process aircraft (e.g., number of aircraft per hour for an airport).
Concept Validation	*Concept validation* is defined as the systematic evaluation of a concept to determine its operational impact on NAS users and service providers. A concept is considered valid if it provides an operational benefit and meets established user and service provider goals related to safety, efficiency, capacity, predictability, flexibility and accessibility.
Efficiency	*Efficiency* refers to performing an operation in the least wasteful manner.
Experiment Plan	*Experiment plan* refers to a plan, specifically developed, to define scope, objectives, methodology, and schedule of a specific experiment.
Fast-time Simulation	*Fast-time simulation* refers to mimicking or emulating an operation using mathematical, statistical and analytical methods. Generally, a fast-time simulation emulates an Air Traffic operation for a period of time using Monte-Carlo simulation or queuing methods. The fast-time simulation is useful for conducting analysis of capacity, delays, and efficiency. Fast time refers to the time taken to emulate the operation. Since it uses mathematical, statistical and analytical principles and power of computing, the time required for emulating the operation is smaller than the real operation itself, hence the term fast-time.
Flexibility	*Flexibility* of the ATM system allows ATS to evaluate its ability to permit users to adapt their operations to changing conditions.
Functional Allocation	*Functional allocation* refers to allocating functions to human and machines. A concept may be achieved by different levels of functional allocations between human and machines.

Functional Decomposition	*Functional decomposition* refers to breaking down higher level functions (e.g., separation assurance) to lower level tasks and activities that need to be accomplished to achieve the function. Functional decomposition is necessary to conduct functional allocation.
Metrics	*Metrics* refers to a set of measures that are used to examine the benefits and feasibility of an operational concept. Examples of metrics include controller workload (e.g., number of communications), situation awareness, safety (e.g., number of separation violations), capacity (e.g., throughput). The term *measures of effectiveness* and *metrics* are used interchangeably.
Modeling	*Modeling* refers to an analytical or mathematical representation of some system operation (e.g., analysis using formulas of a system or operation). Examples of modeling studies include safety assessment as a result of increased traffic load on the system.
Operational Concept	*Operational concept* refers to a way of conducting part of air traffic control and management operations. A concept may refer to technology, procedures, and automation that can be used for air traffic control and management operations. An operational concept generally describes the way ATS services could be provided.
Paper Study	*Paper study* refers to any study that can be done without using special tools or equipment. It is also referred to as a *Staff Analysis*. A paper study normally involves preliminary assessment of a concept such as assessment of pros and cons. The product of a paper study is normally a white paper or technical note. The paper study may involve some level of analytical assessments.
Performance	*Performance* refers to delivery achieved from a system, operation, or human. Examples of performance measures include safety, capacity, efficiency, and reliability. Performance requirements generally used to derive metrics, baseline and benchmarks.
Predictability	*Predictability* refers to variability in the ATM system as experienced by the user. The higher the variability, the lower the predictability. The variability is s result of the inherent uncertainty that accompanies the operation of the complex aviation system. An example of predictability is a deviation from the planned schedule of a flight with higher the predictability, lower the deviation and vice-versa. The predictability of flight depends on system (e.g. other traffic, capacity of runway) as well as environmental factors (e.g., weather, winds).
Problem Definition Phase	*Problem definition phase* refers to identifying problem statements or issues associated with an operational concept that need investigation. The *problem definition phase* may involve preliminary analysis based on prior research or a paper study.
Productivity	*Productivity* refers to the ratio of output and input. It normally refers to resources spent and output derived from the resources. Examples of productivity include number of aircraft handled per controller or number of facilities maintained by a specialist. With automation, the

	productivity generally improves. There is a greater emphasis on improving productivity because normally the budget is limited or is reduced and yet air traffic continuously increases over the years.
Rapid Prototyping	*Rapid prototyping* refers to the technique of developing a model (e.g., display interactions) that mimics the system. The term rapid refers to the ability to quickly develop a system that looks and feels much like a real-system. However, rapid prototype is not an actual system and it normally lacks the necessary performance of an actual system. Normally rapid prototyping is used for systems that are not built as of yet or for system interfaces that need exploration prior to their building.
Real-time Human-in-the-loop Simulation	*Real-time Human-in-the-loop (HITL)* simulation refers to mimicking or emulating a system or operation using humans as participants. The real-time HITL normally uses operationally similar equipment for simulation. One of the purposes of real-time HITL is to examine the impact of an operation on an operator. Since the real-time HITL emulates the operation as close to its reality as possible, the time required for emulation is the same as its actual operation, hence the term real-time.
Safety	*Safety* refers to freedom from risk or accidents. Safety is the most important performance criteria of the ATS. An example of a safety metrics is to reduce the number of weather related accidents by 15% by year 2002 as compared to 1999.
Service Providers	*Service providers* (or air traffic service providers) include air traffic controllers, supervisors, facility staff and managers, and traffic management specialists who provide services to users operating within the U.S. National Airspace System. Currently, air traffic service providers operate within Command Control Center, Air Route Traffic Control Center, Flight Service Stations, Airport Traffic Control Towers, Terminal Radar Approach Control, and Oceanic Air Traffic Control domains.
Services	As defined by the Air Traffic Service Performance Goals, *Services* (or operational services) refer to separation assurance, air traffic management, aviation information dissemination, navigation, landing, airspace management, spectrum management, search and rescue, and aviation assistance.
Simulation	*Simulation* is defined as emulating or mimicking a certain operation. Simulation can be conducted using mathematical and analytical models (generally referred to as fast-time simulations) or using human participants (generally referred to as real-time human-in-the-loop simulation). Normally, the purpose of a simulation is to investigate the feasibility and benefits of an operational concept or a proposed improvement prior to implementation.
Situation Awareness	*Situation awareness* is defined as an operator’s ability to integrate information related to state of a task, operation, equipment and environment; make necessary predictions; and take the necessary

	decisions and suitable actions. Several other definitions of situation awareness exist.
Synthesis Phase	*Synthesis phase* refers to interpreting data and results gathered in the analysis phase. The s*ynthesis phase* may include interpretation and recommendation based on multiple studies.
Users	*Users* (or National Airspace System users) include national and international air carriers, general aviation, and military users who operate in the U.S. National Airspace System.
Validation Process	*Validation process* describes the overall approach for conducting validation of operational concepts.
Workload	*Workload* is defined as combined cognitive and physical demands experienced by an operator. The workload experienced by an operator depends on the task, skill, knowledge, experience, abilities, and training. Generally, workload is considered as an operator's response to taskload.